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On the FORCE *of* TESTIMONY *in eſtabliſhing* FACTS *contrary to* ANALOGY. *By the Rev.* MATTHEW YOUNG, *D.D. S.F.T.C.D. & M.R.I.A.*

> Il n'eſt pas ſi glorieux a l'eſprit de Geometrie de regner dans la Phyſique que dans les choſes de Morale, ſi caſuelles, ſi compliquées, ſi changeantes. Plus une matiere lui eſt oppoſé et rebelle, plus il a d'honneur a la dompter.
>
> FONTENELLE.

Read, Feb. 3d 1798. ARISTOTLE obſerves, that the chief characteriſtic of quantity is, that it is that by which any thing may be denominated *equal and unequal.* Præd. p. 34. Ed. Sylb. Every thing therefore is ſaid to admit of quantity, which is capable of more and leſs. Hence quantities are reduced to two claſſes, thoſe which conſiſt of parts, and thoſe which are eſtimated by degrees: accurately ſpeaking, the former alone are quantities, the latter are ſo only metaphorically.
“ Propter ſimilitudinem dicuntur quantitates, quantitas perfec-
“ tionis, quantitas virtutis, intenſionis, valoris, & ſimilium. In
“ his enim eſt ſimilitudo quædam quantitatis, quæ in eo poſita
“ eſt, quod ſicut quantitas molis dicit extenſionem quandam par-

“ tium extra partes, ita & dictæ quantitates ſuo modo quandam “ extenſionem partium habent. Smigl. p. 294” This latter ſpecies of quantity is therefore called “*Quantitas Intenſa & Virtutis*,” Aldrich p. 43; for the eſſential perfections and virtues of things are compoſed of different degrees, in the ſame manner as quantity, properly ſo called, is compoſed of parts. Burgeſd. p. 21. Quantities which conſiſts of parts are alone capable of meaſure, and therefore of mathematical compariſon; while the others, though they admit of more and leſs, yet not being meaſurable, cannot be mathematically compared. Thus different areas, which conſiſt of parts, are meaſurable; but pleaſure and pain, heat and cold, probability and improbability, virtue and vice, which are eſtimated by degrees, are not meaſurable. Crakanthorp therefore deſcribes quantity, by ſaying, that “ it is an abſolute accident, by which things are “ meaſured primarily and *per ſe*,” p. 81. Now to make quantities which conſiſt of degrees, and therefore are not meaſurable, the ſubject of mathematical compariſon, an arbitrary meaſure is aſſigned, by referring them to ſome meaſurable quantity to which they are related. Thus, in the graduation of the thermometer, an arbitrary meaſure is eſtabliſhed for heat and cold, for the degrees of heat are referred to the expanſion of the fluid contained in the thermometer, which is meaſurable, and to which heat is related. In the ſame manner, probability has no meaſure in itſelf; but an arbitrary meaſure is aſſigned to it, by referring it to the ratio of the number of chances by which the event may happen or fail;

and thus it becomes the ſubject of mathematical calculation, in the ſame manner as the degrees of heat.

The ratio of thoſe quantities which conſiſt of parts, cannot always be accurately aſſigned; nevertheleſs, ſince the quantities are finite, they muſt have ſome finite, determinate ratio to each other. Thus the area of a circle to the circumſcribed ſquare cannot be accurately exhibited: in theſe caſes we can, in general, proceed by continual approximations, and aſſign limits within which the true ratio muſt ſubſiſt.

If there be two things, one of which is greater or leſs than the other, they are quantities of the ſame ſpecies: thus when a cannon ball is ſaid to be greater than an orange, the abſtract magnitudes of both are quantities of the ſame ſpecies.

If two things be of the ſame ſpecies, and one of them can be repreſented by an exponent of a given kind, the other is in its nature capable of being expreſſed by an exponent of the ſame kind. Thus if the area of a ſquare be repreſented by a given right line, the area of the inſcribed circle is capable of being repreſented by another right line, though no mathematician has yet been able to ſhew what that line is, by any geometrical conſtruction.

If the velocity of a ray of light incident on a piece of cryſtal be expreſſed by a given number, there is a number which will alſo expreſs its velocity within the cryſtal.

The *active*, *efficient cauſes* of events are thus enumerated in the Ethics of Ariſtotle, " the ſeveral cauſes appear to be nature, ne-" ceſſity, and chance, and beſides theſe, mind or intellect, and " whatever operates by or through man." L. 3. c. 3. Chance therefore is an active, efficient cauſe; but it is alſo *an accidental cauſe*, " ad cauſam per accidens revocatur fortuna et caſus," Burgeſd. Chance therefore is an efficient, accidental cauſe of an event.

The probability of an event, according to De Moivre and Simpſon, is greater or leſs according to the number of chances by which it may happen, compared with the whole number of chances by which it may either happen or fail.

As, ſuppoſing it were required to expreſs the probability of throwing either an ace or duce at the firſt throw with a ſingle die; then there being in all 6 different chances or ways that the die may fall, and only 2 of them for the ace or duce to come upward, the probability of the happening of one of theſe will be $\frac{2}{6}$ or $\frac{1}{3}$.

Wherefore if we conſtitute a fraction, whereof the numerator ſhall be the number of chances whereby an event may happen, and the denominator the number of chances whereby it may either happen or fail, that fraction will be a proper exponent of the probability of happening.

For the ſame reaſon, the probability of its failing will be equal to the number of chances for its failing, divided by the ſum of the number of chances of happening and failing together.

The probability therefore either of the happening or failing of an event is always expreſſed by a proper fraction.

If the number of chances of happening be = 0, that is, if the event be impoſſible, the numerator, and therefore the fraction will be = 0; 0 therefore denotes impoſſibility.

If the number of chances of failing be = 0, that is, if the event be certain, the numerator will be equal to the denominator, and the fraction = 1; unity therefore expreſſes certainty.

Probability therefore extends, as Mr. Locke obſerves, from certainty to impoſſibility.

When the chances for the happening of an event are equal to the chances of its failing, the fraction, expreſſing the probability, is $= \frac{1}{2}$, which is the mean between impoſſibility and certainty.

One event therefore is ſaid to be more probable than another when its probability is expreſſed by a greater fraction; though, in the common acceptation of the word, that only is ſaid to be probable, whoſe probability exceeds half certainty; for if the probability be equal to half certainty, it is called *doubtful*; and if the probability be leſs than half certainty it is ſaid to be *improbable.*

SINCE the chances for happening or failing are equal to the whole number of chances, the probabilities of the happening and failing of the event are together = 1, that is, equal to certainty.

THEREFORE the probability of happening is equal to the difference between certainty and the probability of failing; and the probabity of failing equal to the difference between certainty and the probability of happening.

FROM what has been ſaid it follows, that the probability that a witneſs tells truth in a given inſtance, will be expreſſed by a fraction whoſe numerator is the number of chances for his telling truth, and the denominator the ſum of the number of chances for his telling truth, and for his telling falſhood together.

IN like manner, the probability that an argument is true, is to be eſtimated by the ratio of the number of chances for its truth to the number of chances for its truth and falſhood together.

IT is true, that in neither of theſe latter caſes can we, in general, determine the actual number of chances; nevertheleſs in all caſes where a perſon perceives the probability of an event, he muſt at the ſame time perceive, that there muſt be ſome finite, determinate ratio between the chances for its happening and failing, though he cannot aſſign that ratio; for if there were no finite ratio, either the number of chances for its happening muſt be infinitely greater, or infinitely leſs than the chances for its failing; in the former caſe, the event would appear certain, in the latter impoſſible, therefore probable in neither.

It may perhaps be objected, that if we cannot determine the actual number of chances, all conſideration of the manner of expreſſing mathematically the probability of events is nugatory. But it is by no means ſo; becauſe though we cannot determine the exact degree of credit, which we ought to give to each witneſs, yet we can determine according to what law our belief ought to vary in the caſe of concurring witneſſes, each of equal credibility. Things that are quite unknown, ſays Hartley, have often fixed relations to one another, and ſometimes relations to things known; and as, in Algebra, it is impoſſible to expreſs the relation of the unknown quantity to other quantities known or unknown, 'till it has a ſymbol aſſigned to it, of the ſame kind with thoſe that denote the others; ſo in philoſophy, we muſt give names to unknown quantities, qualities, cauſes, &c not in order to reſt in them, as the Ariſtotelians did, but to have a fixed expreſſion, under which to treaſure up all that can be known of the unknown cauſe, &c. in the imagination, and memory; or in writing, for future enquirers. Vol. I. p. 348.

We can alſo from theſe principles ſhew why after a certain number of witneſſes have atteſted a fact, any farther evidence is ſuperfluous.

These principles likewiſe, as Dr. Waring obſerves, may be applied to the inveſtigation of the probability of the truth of the deciſion by any number of voters, and many other caſes; the probability of each voter voting truly being ſuppoſed given. But, as he alſo obſerves, it is impoſſible to determine the knowledge, integrity, and various influences which actuate each perſon, and conſequently to determine the probability of their voting truly.

But though we cannot determine the actual probability, yet ſince the voters are to be ſuppoſed of equal integrity, knowledge, &c. we can determine the relative probabilities of the truth of the deciſions by different majorities; and on theſe principles Mons. Condorcet has enquired into the laws according to which the majorities, which decide queſtions in deliberative aſſemblies, ought to be regulated.

Thus ſuppoſe the enacting of a new law were propoſed to a deliberative aſſembly, ſuch a majority ſhould be required as would give a very great probability of the juſtice of their deciſion; for it is much better that no law ſhould be enacted than a bad one. A majority of more than one ſingle voice ſeems alſo requiſite in ſome queſtions of a civil nature, as for inſtance in long continued poſſeſſion; for though length of poſſeſſion ſhould not ſuperſede right, yet conſiderable regard ſhould be paid to it, not only for the ſake of the public tranquillity, but likewiſe becauſe in the progreſs of time, there, in many caſes, ariſes a greater difficulty of producing the original titles of property. So that perhaps it would be wiſe to increaſe the majority, requiſite to decide the queſtion, according to the duration of the poſſeſſion. On the other hand, all queſtions which require immediate determination, ſhould be decided even by the leaſt poſſible majority.

It follows therefore, that although we cannot actually aſſign the fraction which expreſſes the credibility of a given witneſs, yet our reaſonings on teſtimony will be rendered more clear, determinate, and extenſive by this notation. And accordingly Dr. Waring, after he lays down the principles for determining the probabilities of events, obſerves that they may be applied to human teſtimony. See his Eſſay on the Principles of Human Knowledge, § 17.

That probability may juſtly be expreſſed by a fraction, certainty being denoted by unity, and impoſſibility by a cypher, will likewiſe appear from the following conſiderations:

If upon the happening of an event, ſays De Moivre, I be entitled to a ſum of money, my expectation of obtaining that ſum has a determinate value before the happening of the event.

If a perſon therefore tells me, that an event has happened, by which I am to receive a ſum of money, my expectation of receiving that ſum has a determinate value, before I certainly know whether that event has actually happened or not.

In all caſes, the expectation of obtaining any ſum is eſtimated by multiplying the value of the ſum expected by the fraction which repreſents the probability of obtaining it. Thus if my probability of obtaining £100 be $\frac{3}{5}$, my expectation will be $= \frac{3}{5} \times$ £100 = £60.

Therefore it neceſſarily follows, that the probability of obtaining the ſum is equal to the value of the expectation, divided by the value of the thing expected. And ſince the expectation is neceſſarily determinate, ſo likewiſe is the probability. Now my expectation, derived from the report of the witneſs, muſt be either equal to, greater, or leſs than the expectation derived from an equal chance; the probability will therefore be either equal to, greater, or leſs than an equal chance; therefore the probability in the former caſe is homogeneous with the probability in the latter; but the latter is capable of being expreſſed fractionally, therefore ſo alſo is the former.

Suppose a perſon of good character tells me, that an event has happened by which I am to receive £100; there will hence ariſe an expectation in my mind, which muſt be of ſome determinate value: for there is a ſum leſs than £100, for which I would ſell my chance, otherwiſe I muſt conſider the report of the witneſs as abſolutely certain; alſo, that there is a ſum for which I would not ſell my chance, is likewiſe evident, for if not, I muſt have no reliance whatſoever on the witneſs. We can therefore aſſign limits, within which the meaſure of my expectation ſubſiſts; and therefore there muſt be ſome intermediate, determinate ſum, which is the meaſure of my expectation. Let this expectation be $= \frac{1}{n} \times$ £100; then $\frac{1}{n} \times \frac{£100}{100} = \frac{1}{n}$ expreſſes the probability that the witneſs tells truth; or rather is the meaſure of my belief in his veracity.

This expectation is to be reſolved, as Hume and Waring obſerve, into the conſtitution of our nature; the Supreme Being having impreſſed on our minds a faculty for the ſource of all our knowledge reſpecting exiſtence, namely, a neceſſary or impulſive belief of the future from the paſt, viz. that what has, for the time paſt of our lives, been joined together or conſtantly ſucceeded each other, will for the future be joined together, or be found in the ſame order to ſucceed each other. So that having obſerved, that in certain circumſtances men tell truth, there ariſes, by the conſtitution of our nature, or as ſome hold, by aſſociation, an expectation, that, in like circumſtances, other men will likewiſe tell truth.

But the expectation, in the ſame circumſtances of an event, will be different according to the conſtitution of the expectant; for, according to his antecedent experience, knowledge, prejudices, and paſſions, the arguments for or againſt the probability of the event will appear more or leſs numerous, more or leſs cogent; ſo that in given circumſtances of an expected event, or of a propoſed argument, the apparent probability will very much depend on the conſtitution of the individual, which therefore muſt be conſidered as a principal element in the computation.

In like manner, in the courſe of nature, we conclude, by experience, from things paſt to the future; and when the analogy is properly inſtituted, the events ſeldom or never differ; the more the preceding qualities are which agree, the greater on that account is the probability that the events will be the ſame: and from greater experience we gradually conclude a greater degree of probability, though, in general, we cannot aſſign a reaſon for it. Deinde nec illud quenquam latere poteſt, ſays Bernouilli, quod ad judicandum hoc modo (nempe empirico) de quopiam eventu, non ſufficiat ſumpſiſſe unum alterumque experimentum, ſed quod magna experimentorum requiratur copia; quando & ſtupidiſſimus quiſque, *neſcio quo naturæ inſtinctu, per ſe & nullâ prævià inſtitutione (quod ſanè mirabile eſt)* compertum habet, quo plures ejuſmodi captæ fuerint obſervationes, eò minus a ſcopo aberrandi periculum fore. Ars Conjectandi, pag. 225.

From having obſerved, that iron has floated ten thouſand times on quickſilver, there ariſes an expectation, that it will likwiſe float on it in the next trial; but this expectation is not certainty. It does not follow, ſays Hartley, that becauſe a thing has happened a thouſand or ten thouſand times, that it never has failed, nor ever can fail. Vol. II. p. 142.

THE ſources therefore of probability are of two ſpecies; the firſt comprehends thoſe probabilities, which are derived from conſidering the number of cauſes, which may influence the truth of the propoſition: the other is founded ſolely on experience, from which we conclude, that the future will be like the paſt; at leaſt when we are aſſured, that the ſame cauſes, which produced the paſt, ſtill exiſt and are efficient. Thus, firſt, let us ſuppoſe, that 30,000 ſlips of paper are contained in a wheel, of which 10,000 are black, and 20,000 are white; and that it is required to determine what are the odds, that I ſhall at random draw a white paper. In this caſe, from the nature of things we perceive, that the number of chances for drawing a white paper is 20,000, and the whole number of chances is 30,000, therefore the probability of drawing a white paper is $\frac{20,000}{30,000}$ or $\frac{2}{3}$ of certainty; and the probability of drawing a black paper is $\frac{1}{3}$ of certainty. But ſuppoſe that I am ignorant of the contents of the wheel, and know only in general, that it contains ſeveral white and ſeveral black papers, in this caſe if it be required to determine the probability of drawing a white paper, we muſt proceed by trials, that is, we are to draw out a paper and obſerve its colour, then replacing it, we are to draw out a ſecond, which is to be replaced likewiſe, then a third, a fourth, and ſo on. It is clear, ſays Diderot, that the firſt drawn paper, being white, gives but a very low degree of probability that the number of the white exceeds that of the black; a ſecond white one being drawn would encreaſe this probability, a third would augment it. At length, if a great number of white papers ſhould be drawn out, without interruption, we would conclude that they were all white; and that with ſo much the more probability as we ſhould have drawn out more papers. But if, of the three firſt ſlips of paper, two ſhould appear to be white and one black, we would infer, that there was ſome low degree of probability, that there was twice as many white papers as black. If of the ſix firſt drawn papers, four ſhould be white and two black, this probability would encreaſe; and it would encreaſe ſo much the more in proportion, as the number of trials ſhould continually confirm the ſame proportion of the white papers to the black.

THIS manner of determining, probably, the ratio of the chances for the happening of an event to thoſe of its failing, is applicable to every thing which is contingent in nature.

IT may be aſked, ſays Diderot, whether this probability, admitting of infinite increaſe by a ſeries of repeated experiments, can arrive at length at certainty; or whether theſe increments are ſo limited, that diminiſhing gradually, they can at length produce only a determinate degree of probability.

M. BERNOUILLI has anſwered this queſtion in his Treatiſe De Arte Conjectandi, Part the Fourth. He there ſhews, that the probability which ariſes from repeated experiments, encreaſes continually in ſuch a manner, as to approach without limit towards certainty. His calculation ſhews us, provided the queſtion relates only to a particular caſe, how many times an experiment muſt be repeated in order to arrive at an aſſigned degree of probability. Thus in the caſe of a wheel which contains an unknown number of white and black ſlips of paper, ſuppoſe it were required to determine the ratio of the number of the white to the black; M. Bernouilli finds, that in order that it may be a thouſand times more probable, that there are two black papers for three white, rather than any other ratio, it would be neceſſary to make 25,550 experiments; and in order that it might be 10,000 times more probable, it would be neceſſary to make 31,258 trials; and in order that it ſhould be 100,000 times more probable, 36,966 trials would be requiſite; and ſo on ad infinitum, continually adding 5,708 experiments, according as the probability encreaſes in a decuple proportion. So that the number of experiments is the logarithm of the degree of probability produced. And ſince in high numbers the logarithm.

logarithms encreaſe nearly in the ſame proportion with the abſolute numbers, it follows, that the probability that a future event will happen in the ſame manner as in previous trials, will be nearly proportional to the number of theſe previous experiments.

By this it is demonſtrable, that the experience of the paſt is a principle of probability for the future; and that the more frequently we have experienced an event to happen, the greater reaſon have we to expect, that it will happen in the next trial. Now ſince in order that we ſhould have a given degree of probability for the events happening in a particular way, a certain number of experiments is requiſite, it follows converſely, that a given number of experiments will produce ſome determinate degree of probability. This probability, we may perceive, depends merely on the number of experiments; ſo that, this number being the ſame, the degree of probability will be the ſame whatever be the ſpecific nature of the event.

Hence therefore, ſince the inference which we make with reſpect to the mechanical phænomena of nature, as well as with reſpect to the veracity of human teſtimony, are both equally derived from experience of the paſt, if the teſtimony be of ſuch a nature as has never deceived us, the probabilities in both caſes will bear to each other ſome determinate ratio, which, however ignorant we may be of the principles of the calculation, depends on the number of trials which we have reſpectively made with reſpect to them.

It is true that Mr. Price, in his Eſſay on Miracles, p. 391, ſeems to think, that our expectation of the future from the paſt, is not to be reſolved into the conſtitution of our nature, but to *knowledge*; and this knowledge he ſeems to think is *intuitive.* "If," ſays he, "out of a wheel, the particular contents of which "I am ignorant of, I ſhould draw a white paper a hundred "times together, I ſhould *ſee* that it was *probable*, that it had "more white papers than black, and therefore ſhould expect to "draw a white paper the next trial." But here Mr. Price ſeems, unknowingly, to maintain the principle which he controverts; for we perceive the truth of axioms intuitively, either by the conſtitution of our nature, or by aſſociation which is reſolvable into it; and ſince we perceive the probability of propoſitions reſpecting exiſtence, as he aſſerts, in the ſame manner, it follows that we muſt perceive this probability likewiſe, either by the conſtitution of our nature, or by an aſſociation which is reſolvable into it. In fact, all probable propoſitions muſt be ſo either becauſe they are the concluſions of ſyllogiſms, one of whoſe premiſes at leaſt is probable, or becauſe they are primitive probable propoſitions. That there muſt be ſuch primitive, probable propoſitions, is evident, when we conſider that if a propoſition is probable only becauſe it is deduced from premiſes, one of which at leaſt is probable, then this premiſe muſt likewiſe be probable for the ſame reaſon; and thus there would be a proceſs ad infinitum, which is abſurd. Theſe primitive probable propoſitions are thoſe only which are the inferences we make of future events from the paſt. That theſe inferences are not certain is admitted; that they are alſo primitive inferences is manifeſt, becauſe there is no medium by which the inference is made out. There are therefore original and primitive probable propoſitions, in the ſame manner as there are original and primitive certain propoſitions, which are called axioms. But to aſcribe the former to *intuitive knowledge* ſeems an abuſe of language, intuition having been univerſally confined to the perception of axiomatical truths.

I KNOW it has alſo been maintained by ſome Metaphyſicians, that teſtimony does not derive its evidence from experience; but that it has a natural and original influence on belief, antecedent to experience. Let us then proceed to examine the arguments by which they endeavour to eſtabliſh this poſition.

FIRST, it is to be remarked, ſays Mr. Campbell, that the earlieſt aſſent, which is given to teſtimony by children, and which is previous to all experience, is in fact the moſt unlimited; that by a gradual experience of mankind, it is gradually contracted, and reduced to narrower bounds. To ſay therefore, that our *diffidence* in teſtimony is the reſult of experience, is more philoſophical, becauſe more conſonant to truth, than to ſay, that our *faith* in teſtimony has this foundation. In reply to this arguing, let us conſider the progreſs of the human mind; the firſt part of our education conſiſts in leſſons of caution againſt danger; take care of this fire, ſays the affectionate nurſe, it will burn you; of that knife, it will cut you; if you fall, you will be bruiſed, &c. Theſe cautions are daily and hourly verified by experience; the child puts its hand towards the candle or the fire, and it is ſoon warned by pain to withdraw it; and ſo in other caſes. Our earlieſt aſſent therefore is the moſt unlimited, becauſe derived from an experience that has never failed to confirm the truth of the witneſs. Soon however this uniform veracity of the witneſs begins to fail; the parent gives medicine to the ſick child; in the next inſtance; artifice is uſed to induce him to take the bitter draught; it is ſaid to be ſweet and pleaſant to the taſte, the child is deceived and drinks. Here begins diſtruſt; diſtruſt therefore and confidence have both the ſame origin, to wit experience: nor can any metaphyſician produce an inſtance, in which belief in teſtimony has preceded all experience.

2dly, Dr. Reid is of opinion, that there is an inſtinctive principle in the human mind to ſpeak truth; and that there is another inſtinctive principle, the counterpart of the former, which he calls the principle of credulity, or a diſpoſition to confide in the veracity of others, and to believe what they tell us.

THAT ſuch a principle exiſts in our own minds, can be determined only by our cônſciouſneſs of it; that it reſides in others can be diſcovered only by their words and actions, that is, by experience.

IN confirmation of what is here advanced, I ſhall tranſcribe the more concluſive argument of Dr. Prieſtley.

THAT any man, ſays Dr. Prieſtley, ſhould imagine, that a peculiar inſtinctive principle was neceſſary to explain our giving credit to the relations of others, appears to me, who have been uſed to ſee things in a different light, very extraordinary; and yet this doctrine is advanced by Dr. Reid, and adopted by Dr. Beattie. But really what our author ſays in favour of it, is hardly deſerving the ſlighteſt notice.

" IF credulity," ſays he, " were the effect of reaſoning and
" experience, it muſt grow up and gather ſtrength in the ſame
" proportion as reaſon and experience do. But if it is the gift
" of nature, it will be ſtrongeſt in childhood, and limited and re-
" ſtrained by experience; and the moſt ſuperficial view of human
" life ſhews, that this laſt is really the caſe, and not the firſt."

THIS reaſoning, continues Dr. Prieſtley, is exceedingly fallacious. It is a long time before a child hears any thing but truth, and therefore it can *expect* nothing elſe. The contrary would be abſolutely miraculous. Falſhood is *a new circumſtance*, which he likewiſe comes to expect, in proportion as he has been taught by experience to expect it. What evidence can we poſſibly have of any thing being neceſſarily connected with experience, and derived from it, beſides its never being prior to it, always conſequent upon it, and exactly in proportion to it?—Prieſtley's Examination, &c. p. 82.

3dly, Mr. Price argues, that experience is not the ground of the regard we pay to human teſtimony, for were it ſo, this regard would be in proportion to the number of inſtances, in which we have found, that it has given us right information, compared with thoſe in which it has deceived us. But this is by no means the truth. One action, ſays he, or one converſation with a man may convince us of his integrity, and induce us to believe in his teſtimony, though we had never, in a ſingle inſtance, experienced his veracity. His manner of telling the ſtory, its being corroborated by other teſtimony, and various particulars in the nature and circumſtances of it, may ſatisfy us, that it muſt be true. See his Eſſay on Miracles, page 399.

But is not all this confidence the reſult of experience? Why ſhould the *manner* of telling a ſtory induce us to believe it, unleſs we had previouſly learned by experience, that this *manner* was an indication of veracity. 2dly, In like manner, the *circumſtances* of a ſtory induce us to believe it, becauſe we have found by experience, that theſe circumſtances diſcover the integrity or ſkill of the witneſs. 3dly, Concurrent teſtimony is not juſtly introduced into this argument by Mr. Price, becauſe the foundation of the evidence of diſcrete teſtimony muſt be aſcertained, before we can proceed to the eſtimation of concurrent teſtimony; and alſo, more particularly, becauſe the greater ſtrength of concurrent teſtimony is equally admitted both by thoſe who deny the dependence of the regard we pay to teſtimony on experience, and thoſe who aſſert it. 4thly, In our experience of a courſe of nature, our conviction is not always in proportion to the number of experiments *in a given inſtance*, though it is in proportion to the whole number of experiments on which our belief is founded: thus if a new metal be diſcovered which is ſpecifically heavier than lead, we conclude from that ſingle experiment, that it will ſink in water, with a confidence as great as that lead itſelf, on which we have made ſo many experiments, will ſink in water. And the reaſon of this is, becauſe we transfer to this particular inſtance the ſum of our experiments on other ſubſtances ſpecifically heavier than water, which have always been obſerved to ſink in it. And in this way it is, that the regard we pay to the report of a witneſs, is not always in proportion to the number of inſtances in which we have found that *he* has told truth, namely becauſe we apply to him the ſum of all thoſe indications of veracity, which in previous inſtances we have obſerved in others.

4thly, Mr. Price obſerves, that we feel in ourſelves that a regard to truth is one principle in human nature; and we know, that there muſt be ſuch a principle in every reaſonable being.

But how do we know, that there muſt be ſuch a principle in every reaſonable being?—This implies, that other reaſonable beings are like us; and that they are ſo is to be diſcovered only by experience. When by experience we have diſcovered, that in ſimilar caſes they act in the ſame manner that we do ourſelves, we then infer, that they have the ſame tendencies, the ſame paſſions, the ſame regard to truth that we ourſelves have. So that this inference is preciſely of the ſame nature with that, which we make reſpecting the phænomena of nature. We have found that a piece of lead ſinks in water; another piece of metal occurs, which is found by experience or obſervation to reſemble lead; whence we infer, that it likewiſe will ſink in water. So that our inference in this caſe is founded on that conſtitution of our nature, by which we have a confidence in the future from our experience of the paſt: and our confidence in teſtimony has no other origin.

Having now ſhewn, that our belief in a courſe of nature and in human teſtimony is equally derived from experience, that the degree of probability is proportional to the number of previous experiments when they are very numerous, and that any given degree of probability is juſtly expreſſed by a fraction which denotes the value of our expectation; it follows, that theſe probabilities derived from our experience reſpecting any ſpecies of natural phænomena, and the veracity of human teſtimony are homogeneous quantities; and therefore may be juſtly compared with each other.

But the conviction produced by teſtimony is capable of being carried much higher than the conviction produced by other experience; and the reaſon is this, becauſe there may be concurrent teſtimonies with reſpect to the truth of the ſame individual fact, whereas there can be no concurrent experiments with reſpect to an individual experiment. There may indeed be analogous experiments, in the ſame manner as there may be analogous teſtimonies; but in a courſe of nature there is but one continued ſeries of events, whereas in teſtimony, ſince the ſame event may be obſerved by different witneſſes, their concurrence is capable of producing a conviction more cogent than any which is derived from any other ſpecies of events in the courſe of nature. In material phænomena, the probability of an expected event depends ſolely on analogous experiments, which have been made previous to the event; and this probability admits of indefinite encreaſe from the unlimited encreaſe of the number of theſe precedent experiments. The credibility of a witneſs ariſes likewiſe from our experience of the veracity of previous witneſſes, and admits of unlimited encreaſe, according to their number; and the law of its encreaſe is, of courſe, the ſame with that derived from phyſical events. There is however another ſource of the encreaſe of teſtimony, which is likewiſe unlimited, derived from the number of concurrent witneſſes, and its encreaſe on this account follows a law different from the former. The evidence of teſtimony therefore admitting of an unlimited encreaſe on two different accounts, and the probability of the happening of any ſpecific event admitting only of one of them, the former is capable of indefinitely ſurpaſſing the latter.

In order to prove this, we muſt conſider the law which the evidence of concurring witneſſes follows, according to the number of the witneſſes.

Let there be two dies, of the ſame kind, in each of which the number of white faces is m, each alſo having but one black face; and ſuppoſe, that theſe dies being thrown together, it be required to determine, what is the proportion of the number of chances that two white faces will turn up to the number of chances that two black faces will turn up together. The number of combinations of two white faces is the ſquare of m; and the number of combinations of black faces is unity. Therefore the odds that two white faces will turn up rather than two black faces, is as m^2 to 1. The caſes where a black and a white face turn up together are excluded by the nature of the queſtion, becauſe the witneſſes are ſuppoſed to be concurrent, that is, that the faces of the dies are of the ſame colour. In like manner, if there be three dies of the ſame kind as before, the odds that three white faces will turn up together rather than three black faces, will be m^3 to 1; and ſo on, the index of m being always equal to the number of dies.

Now if the number of chances that any witneſſes reſpectively tell truth, to the number of chances of their telling falſhood be as m to 1; the odds that they tell truth rather than falſhood, on ſuppoſition

poſition that they are concurrent, will be determined in the ſame manner, that is, will be as that power of the number of chances of their telling truth, whoſe index is the number of witneſſes, to unity.

The ſeries of antecedents whoſe common conſequent is unity, which expreſs the ratio of the probability of the truth and falſhood of the concurring reporters, being the ſucceſſive powers of a given number greater than unity, encreaſe in geometrical progreſſion, and therefore will at length exceed any number however great. And if concurring reporters be all of equal credibility, their number may be ſo far encreaſed as to produce a probability greater than any that can be aſſigned.

For let any propoſed degree of probability be $= \frac{a}{a+1}$; and let the probability that a given witneſs tells truth be expreſſed by the fraction $\frac{b}{b+1}$, b being leſs than a; take ſuch a power b^n of b as that it ſhall exceed a, and let n be the number of witneſſes, then will the probability of the veracity of the concurrent witneſſes be expreſſed by the fraction $\frac{b^n}{b^n+1}$, which is greater than the fraction $\frac{a}{a+1}$; becauſe unity, the given difference of the numerators and denominators bears a leſs proportion to the greater quantity b^n, and therefore the quantities b^n and $b^n + 1$ are more nearly equal than the numerator and denominator of the fraction $\frac{a}{a+1}$.

It is manifeſt, that where the credibility of each witneſs is very great, a very few witneſſes will be ſufficient to overcome the probability derived from the nature of the fact. Thus ſuppoſe the latter probability $= \frac{6560}{6561}$; and let us ſuppoſe that each witneſs tells truth only nine times for once that he tells falſhood; that is, let the probability of the truth of his report be equal only to $\frac{9}{10}$; then four ſuch concurring witneſſes will be ſufficient to produce belief.

After a certain number of concurring witneſſes have given their teſtimony in confirmation of the truth of a fact, any farther encreaſe of their number is ſuperfluous; becauſe the difference between unity and the fraction expreſſing the probability, which is the reſult of their concurrent teſtimony, is indefinitely little; and all that an indefinite encreaſe of the number of witneſſes could do, would be to diminiſh that indefinitely little defect.

Yet that probability, in caſes of teſtimony, admits of an unlimited encreaſe, is evident; becauſe the limit of probability is certainty, but the denominator of the fraction, which expreſſes probability, always exceeds the numerator by unity; therefore the fraction can never be equal to unity; that is, no finite number of concurrent reporters can produce abſolute certainty.

By this unlimited encreaſe is to be underſtood the actual, not ſenſible probability; for the indefinitely little defect from certainty is capable of mathematical computation, as well as the greateſt quantity, though it be imperceptible by the human mind. We are therefore juſtified in concluding, that the evidence of human teſtimony effectually attains its maximum, becauſe it arrives at ſuch a degree, as that any further increaſe of it is imperceptible. And the like takes place in extenſion; ſuppoſe a yard to be encreaſed by the hundred thouſandth part of an inch, and by half that quantity, and by the $\frac{1}{8}$, and $\frac{1}{16}$ &c. ad infinitum; the increment of this line would be imperceptible, and yet the line would never attain its maximum.

If the chances for the truth and falſhood of the report of each of any concurrent witneſſes be equal, no number whatever of ſuch witneſſes can render an event probable, by their teſtimony. Becauſe the number of chances of their coincidence in falſhood encreaſes in the ſame proportion with the number of chances for their telling truth. Let their number $= n$, ſince the probability that each witneſs tells truth is $= \frac{1}{2}$, the meaſure of the probability of the concurrent witneſſes will be $= \frac{n}{2n} = \frac{1}{2}$.

If it be improbable that each witneſs tells truth, that is, if the number of chances that each tells falſhood, be to the number of chances of his telling truth, in any ratio greater than the ratio of equality, the greater the number of concurrent witneſſes, the leſs will be the probability of the truth of their report; becauſe the greater will be the number of their combinations in falſe report in proportion to the number of their coincidences in truth. Thus if there be three witneſſes, each of whoſe credibility is meaſured by $\frac{1}{5}$, that is, if there be one chance only for the veracity, and four chances for the falſhood of each, then will the improbability of the truth of their report be meaſured by $\frac{1}{65}$.

THIS concluſion, as Mons. Condorcet obſerves, leads us to a very important remark, which ſhews how unfit numerous popular aſſemblies are for deliberation; for ſince in ſuch aſſemblies, when we conſider the ignorance and prejudices of the voters, we muſt eſtimate the probability that each will vote right at leſs than an even chance, it follows, that the more numerous the aſſembly, the greater will be the probability that their deciſions will be falſe. And hence we perceive, what political evils muſt follow from the determinations of an ignorant democracy. But in a well informed and impartial aſſembly, the more numerous the voters, the greater will be the probability of the rectitude of their deciſions.

HENCE, by the way we may remark, that Dr. Halley's mode of computing the probability of the report of concurrent witneſſes is erroneous. According to him, the calculation is to be made in following manner; if the firſt witneſs gives $\frac{a}{a+c}$ of certainty, and there is wanting of it $\frac{c}{a+c}$, the ſecond atteſter will add $\frac{a}{a+c}$ of that $\frac{c}{a+c}$; and conſequently leave wanting only $\frac{c}{a+c}$ of that $\frac{a}{a+c} = \frac{c^2}{\overline{a+c}^2}$. And in like manner, the third atteſter adds his $\frac{a}{a+c}$ of that $\frac{c^2}{\overline{a+c}^2}$, and leaves wanting only $\frac{c^3}{\overline{a+c}^3}$, &c.

Hence, he obſerves, it follows, that if a ſingle witneſs ſhould be only ſo far credible as to give me the half of full certainty; a ſecond of the ſame credibility, joined with the firſt, would give me $\frac{3}{4}$ths, a third $\frac{7}{8}$ths, &c. which appears to be falſe; for we have ſhewn above, that no number of ſuch reporters could produce an aſſurance greater than that of an even chance, for the truth or falſhood of the fact.

The fallacy of his argument lies in this, that he ſuppoſes all the individual concurrent witneſſes to produce unequal degrees of aſſurance, which is evidently a falſe poſition; ſince they are all of equal credibility and equally concurrent, and therefore contribute equally in producing our aſſurance.

Dr. Waring, whoſe ſolution is eſſentially the ſame with Halley's, ſays, if there be two different arguments (or witneſſes) entirely independent of each other, in ſupport of a fact, whoſe probabilities let be $\frac{p}{a}$ and $\frac{q}{a}$; then will the probability in ſupport of the fact, reſulting from both arguments (or witneſſes) be $1 - \frac{(a-p)\,(a-q)}{a_2}$: for if the probabilities in ſupport of it are reſpectively $\frac{p}{a}$ and $\frac{q}{a}$, then will the reſpective probabilities of its failing be $1 - \frac{p}{a} = \frac{a-p}{a}$, and $1 - \frac{q}{a} = \frac{a-q}{a}$; and conſequently the probability of failing from both will be $\frac{a-p}{a} \times \frac{a-q}{a}$; whence the probability of the fact reſulting from both will be $1 - \frac{a-p}{a} \times \frac{a-q}{a}$.

In this argument there is one ſtep, which appears inadmiſſible; it is aſſumed, that if the probability of failing from both, or rather of both failing, be $= \frac{a-p}{a} \times \frac{a-q}{a}$, then $1 - \frac{a-p}{a} \times \frac{a-q}{a} =$ the probability of happening from both, which does not appear to be true; becauſe $1 - \frac{a-p}{a} \times \frac{a-q}{a}$ is equal to the probability of both happening, together with the probability of one happening and the other failing. Thus if there be an even chance for both, $\frac{a-p}{a} = \frac{a-q}{a} = \frac{2-1}{2} = \frac{1}{2}$; then $\frac{1}{4} =$ the probability that both will fail; alſo $\frac{1}{4} =$ the probability that both will happen, and $\frac{2}{4} =$ the probability that one will happen, and the other fail; therefore $1 - \frac{1}{4} = \frac{1}{4} + \frac{2}{4} =$ the ſum of the probabilities that both will happen, and that one will happen and the other fail. This mode of calculation adopted by Dr. Waring, however it may hold in joint annuities, where the deſired end is equally anſwered, whether one or all of the lives attain the propoſed period, will not equally apply to the conjoint probability of arguments, or concurring witneſſes, where the evidence fails either when the arguments are all falſe, or are oppoſed to each other.

If the witneſſes that atteſt a fact, or the voters that decide on a queſtion, contradict each other, and it be required to determine what is the reſulting probability of the truth of the fact or of the deciſion upon the whole, we are to proceed thus: firſt compute the odds that the affirmative witneſſes are right, or the ratio of the number of chances of their being right to the number of chances of their being in errror; proceed in the ſame manner with the negative witneſſes; then the product of the number of chances that the affirmative witneſſes are right, into the number of chances that the negative witneſſes are miſtaken, will be the number of chances for the truth of the fact; and the product of the number of chances that the affirmative witneſſes are miſtaken, into the number of chances that the negative witneſſes are right, will be the number of chances for the falſhood of the fact; and conſequently the probability of the truth of the fact reſulting upon the whole, will be equal to the former product divided by the ſum of the two products. For example, let there be ſeven voters, of which let four be affirmative and three negative; and let the chance that each votes rightly be the ratio of a to b, then the ratio of a^4 to b^4 will be the odds that the affirmative voters are right; and the ratio of a^3 to b^3 will be the odds that the negative voters are right; and the ratio of $a^4 b^3$ to $b^4 a^3$, or a to b, will be odds reſulting that the affirmative voters are right.

If there were eight voters, the loweſt majority muſt be five and three; and the odds that the affirmative voters were right would be a^5 to b^5; and the odds that the negative voters were right would be a^3 to b^3; and the reſulting odds that the queſtion was juſtly decided would be $a^5 b^3$ to $a^3 b^5$ or a^2 to b^2.

In general therefore it appears, that the odds for the truth of the deciſion, will be that power of the odds that each perſon votes juſtly, whoſe index is the difference between the number of affirmative and negative voters.

And hence we may correct the error of thoſe who imagine, that the probability, *cæteris paribus*, is the ſame, if the proportion of the number of affirmative witneſſes to the number of negative witneſſes be the ſame; whereas the probability is to be eſtimated by the difference of theſe numbers.

We have already remarked, that in the enacting of a new law, we ought to have at leaſt that probability for the expediency of the law, below which a perſon cannot act without imprudence. As the manner of determining this degree of probability is extremely ingenious, I cannot avoid mentioning it. The object to be attained is equivalent to this, that in the enacting of a law, the riſk of error ſhould not be greater than what we diſregard, even where our own life is in queſtion. Buffon and Bernouilli have endeavoured to eſtimate the value of this riſk, but the following method adopted by Condorcet, ſeems to be the beſt. It is obſerved, that from the age of thirty-ſeven years to forty-ſeven, and from eighteen to thirty-three, the riſk men run of dying by accident or diſeaſes of ſhorter duration than a week, encreaſes continually in nearly a regular manner; and it is alſo obſerved, that a man of thirty-three years is not more apprehenſive of ſuch kind of death than a man of eighteen, nor a man of forty-ſeven than a man of thirty-ſeven years; the difference of riſk therefore in theſe caſes is diſregarded: now, from the tables of mortality, it appears, that, in the firſt period, the difference of riſk is $= \frac{1}{301115}$, and in the ſecond $= \frac{1}{144768}$; let us then take the latter, which is the greater, as the limit of that riſk which may be diſregarded, and conſequently $\frac{144767}{144768}$ will be the limit of the aſſurance, which we ought to have in the enacting of a new law.

If we ſuppoſe that the odds that each legiſlator votes juſtly, is ten to one, then will a majority of ſix be requiſite to give the aſſurance required; which in an aſſembly of three hundred is only a majority of one in fifty.

THESE principles, which we have laid down above, may be likewiſe applied, as is manifeſt, to determine the probability of the deciſions in courts of appeal; where the ſame queſtion is ſucceſſively tried before different tribunals.

AND here I cannot avoid obſerving, that Dr. Waring's method of determining the reſulting probability, where different arguments are contradictory, is erroneous. Let P, ſays he, be = the probability reſulting from the arguments in ſupport of the fact, and Q = the probability reſulting from all the arguments againſt the fact; then the probability of all the arguments for the fact will be P—Q, if P be greater than Q; or againſt it = Q—P, if Q be greater than P. See Principles of Human Knowledge, § 10. Now, according to theſe principles, if two witneſſes of equal veracity ſhould contradict each other, the difference between the probabilities for and againſt the fact would be = *o*, that is, the fact would be impoſſible; which evidently cannot be a true inference. But in reality, in this caſe, there would be an equal chance for the truth and falſhood of the fact; for let the odds that each witneſs tells truth be the ratio of a to b, then the odds reſulting that the fact is true, will be the ratio of ab to ba, and the reſulting probability = $\frac{ab}{ab + ab} = \frac{1}{2}$.

AGAIN, if againſt a propoſition which is abſolutely certain, there ſhould occur an argument for the truth of which there was an even chance; the probability reſulting upon the whole, according to Dr Waring, would be no more than an even chance, for $1-\frac{1}{2}=\frac{1}{2}$; which is manifeſtly a falſe inference. In fact, ſince the odds that the propoſition is true are infinite, or as 1 to 0, the reſulting odds muſt always be as ſome finite number to 0, that is, infinite, that is, the propoſition will ſtill be certain.

I HAVE here mentioned ſome circumſtances relative to the nature of the evidence reſulting from concurring and contradictory reporters, not tending directly, it is true, to the eſtabliſhment of the point I propoſed to myſelf, but nearly connected with it; my principal, and I may almoſt ſay, my ſole object being to ſhew, that the evidence of teſtimony can overcome any degree of improbability however great, which can be derived from the nature of the fact.

OUR expectation that a phyſical event, in the courſe of nature, will happen in a particular manner, is founded on previous experience; which experience may be both perſonal and derived; that is, our expectation may be deduced both from our own actual experience, and the reports of others vouching their experience, of the like events, in ſimilar caſes. Since this expectation muſt neceſſarily be of ſome determinate value, depending in ſome manner on the number of experiments either actually made by ourſelves or reported by others, we will ſuppoſe it $= \frac{e}{e+1}$. This argument is founded on an analogy which has never deceived us, and is called, by Mr. Hume, a proof. On the other hand, there is a direct and poſitive teſtimony of a ſingle witneſs, that the contradictory of this event did actually happen; and this is ſuch a teſtimony as both perſonal and derived experience aſſures us has never deceived; the probability of the truth of this teſtimony we will call $\frac{t}{t+1}$; this argument Mr. Hume likewiſe calls a proof, and he ſuppoſes, that it is equal to the former, that is, $\frac{t}{t+1} = \frac{e}{e+1}$. This however is a mere hypotheſis; for they are both probable inferences only, deduced from experience; but it is by no means ſhewn, that the number of experiments made in both caſes are the ſame, or the circumſtances exactly parallel; t therefore may be either equal to, or greater, or leſs than e, in any aſſigned proportion. The evidence of a ſingle witneſs is to be compared with that probability of an event in phyſical phœnomena, which is derived from a ſeries of ſimilar experiments only; becauſe the veracity of human teſtimony conſtitutes one ſpecies of events in the courſe of nature, in the ſame manner as the ſinking of lead in water, or the diſſolution of gold in aqua regia; and therefore is deduced, in the ſame manner as any other ſpecific phœnomenon, from experience, and appears to ariſe, in the ſame manner, from an eſtabliſhed law. This veracity therefore is confirmed by the analogy of other phœnomena, in the ſame manner as any given ſpecies of phyſical phœnomena; inaſmuch as theſe other phœnomena contribute to eſtabliſh the general principle, that *all things* are conducted according to eſtabliſhed laws. If now we conſider the numerous experiments we make every day on the veracity of human teſtimony in certain circumſtances, ſo that our analogy in this caſe is founded on an indefinitely greater number of inſtances than in any other ſpecies of events in the courſe of nature, we may perceive, how the evidence even of a ſingle witneſs may be ſo circumſtanced, as to eſtabliſh an individual phyſical phœnomenon, however contradictory it may appear to our previous experience of ſimilar facts. Let us however ſuppoſe, that the evidence of the ſingle witneſs is leſs than the evidence of experience in any aſſigned proportion, or that t is leſs than e in the proportion of 1 to m; then $mt = e$, and $\frac{e}{e+1} = \frac{mt}{mt+1}$. Take now ſuch a power t^n of t, as that it ſhall be greater that mt, and $\frac{t^n}{t^n+1}$ will be greater than $\frac{e}{e+1}$; that is, if n be the number of witneſſes, each of whoſe veracity is $= \frac{t}{t+1}$, their concurrent teſtimony will be ſufficient to overcome the probability $\frac{e}{e+1}$ derived from the nature of the fact. Hence therefore it follows, that the evidence of teſtimony can approach indefinitely near to certainty; and can at length exceed the evidence of any inference, however cogent, which can poſſibly be deduced from perſonal experience, or from perſonal and derived experience conjointly.

It is to be obſerved, however, that the calculation here ſtated, applies only to the teſtimony of different witneſſes, who ſimply give their evidence as to the truth or falſhood of a propoſed fact; or of witneſſes each of whom has an opportunity of knowing what teſtimony the others have given. This, without doubt, is to take the force of concurrent teſtimony at the greateſt diſadvantage; nevertheleſs, even in this caſe we find, that it has no limit. But there are other caſes in which the leaſt number of concurrent witneſſes, let the degree of their veracity be however ſmall, can afford a probability which ſhall exceed any given degree of probability however great; namely, where the witneſſes have had no means of knowing each others teſtimony, and the fact is attended with contingent circumſtances, which make a part of their depoſition: becauſe the chances of their not concurring in theſe circumſtances, may exceed any given chance. In theſe caſes we obſerve, that even witneſſes who have been obſerved to tell falſhood oftener than truth, may yet produce belief; becauſe here the probability of the truth of their report is not derived from the chances of their coinciding, abſtractedly, in truth or falſhood, but from the chances of their coinciding in circumſtances contingent in their nature, and which have no apparent connection with each other. As for inſtance, if each witneſs ſhould declare, that a celeſtial phænomenon, even ſuch as we had never ſeen, had appeared in a certain region of the heavens, on a certain day, hour, and ſecond; had run over a particular tract, and laſtly diſappeared with circumſtances peculiar and minutely detailed; we muſt perceive, that our belief would not be founded on an enquiry into the characters of the witneſſes, but ſolely into the chances of their concurrence in theſe contingent circumſtances.